Study of Greenhouse Gas Reduction Potential from Semi-Aerobic Landfill

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- Concept of Semi-Aerobic Landfill
- Construction and Sensor Installation
- Monitoring Plan
- Preliminary Results (7 months)
Objectives of Semi-Aerobic Landfill Demonstration Project in Laemchabang

• Applicability of semi-aerobic landfill technology against tropical climate and municipal solid wastes in developing country.

• Design methodology of semi-aerobic technology is developed and evaluated.
Problems of waste treatment in Thailand

- 70% of SWDS are open dumpsites (OD), remaining are landfills (LF).
- Plan to change from OD to LF.
- Landfill structure in Thailand are anaerobic type and generate CH$_4$ continuously.
- Only 2 LFGTE projects (2 MW)
- Looking for sustainable landfill concept which can reduce the local and global pollution in term of gas and leachate emissions
Joint Research

- Laemchabang municipality - Thailand
- Kasetsart University - Thailand
- National Institute for Environmental Studies - Japan
Semi-aerobic landfill technology (SM) is same as “Fukuoka method” that have developed by Prof. Matsufuji.

The SM can change into aerobic waste degradation from anaerobic one at the gravel around the leachate collection pipe.

Air can enter into the landfill site via the leachate collection pipe.

The exit of the leachate collection pipe has to be open to the atmosphere.

The inner leachate level has to be low.
# Construction and Sensor Installation

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
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<tbody>
<tr>
<td>Month</td>
<td>04 05 06 07 08 09 10 11 12</td>
<td>01 02 03 04 05 06 07 08 09 10 11 12</td>
<td>01 02 03 04 05 ...</td>
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<tr>
<td>Construction</td>
<td></td>
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<td></td>
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<td>Landfilling</td>
<td></td>
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<tr>
<td>Sensor inst.</td>
<td></td>
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<tr>
<td>Monitoring</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Elec. Resis.</td>
<td></td>
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</tbody>
</table>

**Main pipe of semi-aerobic test cell**

- $2D = 1000$
- $D = i.d. 500$
- $4D = 2000$

**Main pipe of anaerobic test cell**

- $i.d. 300$
Plan

- Leachate collection pipe with gravel
- Leachate collection pipe without gravel
- Manhole
- Data logging instruments
- Preparation house
- Gas extraction pipe

Semi-aerobic cell

Anaerobic cell

Dimension: Approx. 45 m x 42 m x h 4 m
Volume: Approx. 7,000 m³
• 18 temperature sensors,
• 8 moisture sensors,
• 4 gas extraction tubes, and
• 4 inner leachate collection pans.
Photographs of Demonstration site

Gas ventilation pipe  Semi-aerobic cell  Anaerobic cell

Landfilling (Oct. - Nov. 2009)  Manhole
<table>
<thead>
<tr>
<th>Sensors</th>
<th>Number</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>18</td>
<td>Temperature distribution in each cell</td>
</tr>
<tr>
<td>Moisture</td>
<td>8</td>
<td>Moisture distribution and change with time</td>
</tr>
<tr>
<td>Gas extraction tube</td>
<td>4</td>
<td>Pore gas component and concentration</td>
</tr>
<tr>
<td>Inner leachate pan</td>
<td>4</td>
<td>Fresh inner leachate quality</td>
</tr>
</tbody>
</table>

**Data logging system**

- **Temperature probes** (K-type thermocouple)
- **Moisture sensor** (Theta Probe II)
- **Inner leachate extraction pan**
- **Gas extraction tubes**
# Monitoring Plan

<table>
<thead>
<tr>
<th>Surveys</th>
<th>Interval</th>
<th>Parameters</th>
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</thead>
<tbody>
<tr>
<td>Installed sensors</td>
<td>Every hour</td>
<td>Temperature, moisture change, water balance</td>
</tr>
<tr>
<td>Inner leachate and gas</td>
<td>Every 2weeks</td>
<td>Inner leachate quality, gas component</td>
</tr>
<tr>
<td>Leachate in manhole</td>
<td>Every 2weeks</td>
<td>Leachate quality, mass balance</td>
</tr>
<tr>
<td>Surface Gas flux</td>
<td>Every month</td>
<td>Methane ratio, CH&lt;sub&gt;4&lt;/sub&gt; &amp; CO&lt;sub&gt;2&lt;/sub&gt; flux change</td>
</tr>
<tr>
<td>Electrical resistivity</td>
<td>Every 3months</td>
<td>Moisture distribution, EC change</td>
</tr>
</tbody>
</table>
Preliminary results
(7 months results)

- Gas: flux and gas concentration in waste layer and ventilation pipes
- Leachate: pH, COD, and TKN
- Temperature
- Moisture distribution
- Waste settlementation
- Resistivity
Gas & Flux measurements

- Closed flux chamber method: regular grid pattern at 5m intervals.
- $\text{CH}_4$: Laser Methane Detector - Anritsu SA3C15A (Anritsu Corporation)
- $\text{CO}_2$: DX6210-01 gas sensor (RMT Ltd.)
- GA2000PLUS (Geotech)
- Spatial calculation by Surfer
Average Spatial Emission of CH4 (g/m²/d)

<table>
<thead>
<tr>
<th></th>
<th>AN</th>
<th>SM</th>
<th>AN</th>
<th>SM</th>
<th>AN</th>
<th>SM</th>
<th>AN</th>
<th>SM</th>
<th>AN</th>
<th>SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-09</td>
<td>137.39</td>
<td>30.93</td>
<td>195.09</td>
<td>34.38</td>
<td>55.31</td>
<td>8.16</td>
<td>148.54</td>
<td>25.12</td>
<td>523.70</td>
<td>110.78</td>
</tr>
</tbody>
</table>

Anaerobic cell / Semi-aerobic cell = 4 - 7 times!
### Results of gas concentration (from sampling ports)

<table>
<thead>
<tr>
<th></th>
<th>CH(_4) (%)</th>
<th>CO(_2) (%)</th>
<th>O(_2) (%)</th>
<th>Bal. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-aerobic cell</td>
<td>52.7</td>
<td>44.7</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Ventilation pipe</td>
<td>0.5</td>
<td>0.7</td>
<td>20.7</td>
<td>78.1</td>
</tr>
<tr>
<td>Anaerobic cell</td>
<td>53.3</td>
<td>43.4</td>
<td>0.8</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Results of avg. gas concentration (at 1m. beneath soil cover)
Leachate Results

**pH (-)**

![Graph showing pH results over time for different samples.]

- **20-Dec-09**: SM-Inner Leachate, SM-Effluent, AN-Inner Leachate, AN-Effluent
- **16-Jan-10**: SM-Inner Leachate, SM-Effluent, AN-Inner Leachate, AN-Effluent
- **26-Jan-10**: SM-Inner Leachate, SM-Effluent, AN-Inner Leachate, AN-Effluent
- **3-Mar-10**: SM-Inner Leachate, SM-Effluent, AN-Inner Leachate, AN-Effluent
- **4-Apr-10**: SM-Inner Leachate, SM-Effluent, AN-Inner Leachate, AN-Effluent

**Effluent**

- Sampling port
- Manhole
Temperature in waste body

![Graph showing temperature changes over time in waste body layers.](image-url)
Moisture content in waste body
Moisture Distribution: Electrical Resistivity Tomography (ERT)

- ERT is one of methods, which used to measure the electrical resistivity distribution of the subsurface.
- Direct current is transmitted into the ground by two electrodes, and the potential difference is measured between a second pair of electrodes.
- The apparent resistivity of the subsurface is calculated by using Ohm’s Law and applying a geometric correction.

(Source: www.nga.com/Geo_ser_DC_Tech.htm)
Resistivity in Anaerobic Cell

- Iris Syscal R1 switching 48 multi-electrodes
- Dipole-dipole array

Horizontal scale is 26.99 pixels per unit spacing
Vertical exaggeration in model section display = 1.56
First electrode is located at 0.0 m.
Last electrode is located at 52.5 m.
Resistivity in Semi-Aerobic Cell

Semi-aerobic cell was drier than anaerobic cell!
Waste Settlement

- About 3 cm/month in anaerobic cell
- About 6 cm/month in semi-aerobic cell
Conclusions

- Semi-aerobic method is easy to set up because structure is very simple and low cost for available local materials.
- Emissions of GHG from semi-aerobic cell are significantly smaller than anaerobic cell.
- The leachate from a semi-aerobic cell is more dilute and weaker than anaerobic cell.
Conclusions (con’t)

- Leachate in semi-aerobic cell is discharged as soon as it is collected - reduce the seepage of leachate.
- Release low CH₄ gas from gas ventilation pipes - reduce gas pressure and the chance of accident.
- Settlementation in semi-aerobic cell is higher than anaerobic cell - reduce land consumption
Thank You for your attention!

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